DOCUMENT RESUME

ED 101 326 CS 001 631

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TITLE	Memory Scanning for Pictures by Second and Fourth Grade Children.
INSTITUTION	Connecticut Univ., Storrs. Dept. of Psychology.
PUB DATE	[72]
NOTE	13p.
EDRS PRICE	MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS	Elementary Education; Elementary School Students; Grade 2; Grade 4; *Illustrations; Information Processing; Learning Processes; *Memory; *Reading Processes; *Reading Research; Recall (Psychological); *Visual Perception; Visual Stimuli

ABSTRACT

Twenty children in each of grades 2 and 4 were given a reaction time task of the type in which Sternberg (1969) shows high-speed, serial, exhaustive scanning of information in memory. On each trial subjects were asked to memorize two, four, or six pictures and were then presented with a single picture probe. The subject made a key-pressing response to indicate whet er the probe was in the memory set or not. Older subjects respond more rapidly than younger subjects in all conditions. The results strongly suggest that the memory sets are encoded visually and that the search for the probe is a high speed, exhaustive scan, although, due to difficulty of the task, the outcome is unclear for younger subjects at memory set size 6. The children are scanning memory for the presence or absence of a picture at the rate of 17-20 pictures per second. (Author)

ED101326

PRR-18

Memory Scanning for Pictures by Second and Fourth Grade Children

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Several generalizations about the ways information may be retrieved from memory have been demonstrated by Sternberg (1969) using reaction time experiments. In situations where learning and retention are essentially perfect, Ss are given sets of material to memorize. Following this they are presented with probe stimuli and required to respond whether the probe is an item that was previously memorized. Reaction times for this memory search process are measured. The results of these experiments strongly suggest that the stored information is encoded as an essentially visual abstraction of the original stimulus and that S uses a high-speed, exhaustive scan to search the memory store (Sternberg, 1967, 1969). This process was first shown (Sternberg, 1966) using adult Ss and digit stimuli - characters that are highly familiar symbols that represent numerical quantities which adults are practiced at manipulating and which have well-learned names. Subsequent experiments have shown that the above generalizations hold when the stimuli are nonsense forms or unfamiliar faces (Sternberg, 1969), as well as digits visually degraded (Sternberg, 1967) and numerals presented as digits, words, or dot patterns (PRR-7, this report).

When analyzing reaction times as a function of the number of items in the memory set it is possible to view changes in certain components of the reaction time as corresponding to different operations in the memory search task. The zero-intercept of the function reveals the time required to orient to the probe, choose a response (response decoding), and produce the response; the slope of the function reveals the time required to transform the probe stimulus into the form in which the memory set is encoded, scan the memory set, and match the probe to the memory set items. The memory scanning process thus represented may vary quantitatively as a function of the type of stimuli used while maintaining the basic characteristics of high-speed, serial, exhaustive scanning, as Sternberg (1969) suggests; or the process may change qualitatively (e.g., a self-terminating scan) as a function of the type of stimuli used as argued by Neisser (1967) and Klatsky and Atkinson (1970). The present experiment was designed to explore the nature of the memory search process when pictorial stimuli are used. The pictures used are relatively complex visual stimuli compared to digits but are readily identified with simple names familiar to children. This might make verbal encoding of the memory set more efficient than visual encoding with a consequent shift from a high-speed scanning rate (typically about 50 msec. per item) to search at the rate of inner speech (about 300 msec. per word). The slower rate might then make a self-terminating scan more efficient than an exhaustive scan which would be revealed by slope differences for positive and negative responses. Children of three age levels were used to determine whether there are developmental changes in the process.

Method

Subjects. Twenty children at each of the kindergarten, second and fourth grade levels from the Pomfret Community School, Pomfret, Connecticut, served as Ss. The technique used in this experiment proved too demanding to hold the kindergarten children's attention so data from those Ss will not be presented.

Stimuli. The stimulus materials consisted of ten Stanford-Binet pictures chosen as being familiar to young children. The pictures used were: apple, bed, bird, car, clock, flower, hat, lamp, shoe, tree. Memory sets were 2, 4, or 6 pictures and probes were single pictures that did or did not occur in the associated memory set. All pictures were used equally often as memory items and true or false probes.

Procedure. Each S was presented with three lists of 20 presentation trials each. The first four trials in each list were dummy trials which were not analyzed. The 48 test trials consisted of a random order of 8 each of all the possible memory set size and true or false probe combinations. S was given a brief rest between lists.

Stimuli were presented by means of a Carousel 850 slide projector and appeared on a screen about 3 ft. in front of S. The presentation time for the memory set slides was determined by the number of pictures on a slide. Thus, 2, 4, or 6 item memory sets were exposed for 2 sec., 4 sec., or 6 sec., respectively. The probe picture was presented immediately following the memory set after the interval necessary for a slide change (940) msec.). Exposure of the probe started a Synchron stop clock which was stopped by S's pressing of one of two telegraph keys corresponding to "yes" or "no". S was instructed to respond as rapidly as possible and the instruction was repeated between lists. After each response E recorded the latency and initiated the next trial.

Results

The data were scored in terms of the median latency of correct responses per condition for each S (Katz and Wicklund, 1970). An analysis of variance with a between-S factor of Grade and two within-S factors of Positive Set Size (memory set) and True-False was applied to the median data. The analysis showed significant main effects of Grade ($F = 18.1$, $df = 1/38$, $p < .001$) and Positive Set Size ($F = 28.4$, $df = 2/76$, $p < .001$). Neither the True-False main effect nor any of the interactions achieved statistical significance. Means of the median reaction times across Ss for each of the experimental conditions are shown in Table 1. These means are plotted in Figure 1 where it may be seen that the older Ss consistently respond more quickly than younger Ss and that reaction times increase as a function of the size of the memory set for both true and false probes.

Least squares linear fits to the functions in Figure 1 show that the slopes of the functions for the Fourth grade are 56.50 msec. per item in the memory set for True responses and 57.00 msec. per item for False responses. For the

Second grade, the slope for False responses is 48.25. Although no Grade by True-False or Positive Set Size by True-False interactions were significant, it was felt that a least squares linear fit to the True responses of the Second graders would at best be misleading. Inspection of the error rates shown in Table 2 supports the suggestion that the set Size 6 points in the Second grade might be the least stable since one out of four responses was an error.

Discussion

The data strongly suggest that the children are using a high-speed serial exhaustive memory scan of information encoded visually. Since they are scanning at a rate of 17-20 pictures per second they are obviously not naming them. At least the Fourth graders are using an exhaustive search as evidenced by the virtually identical slopes for True and False responses; and it is suggested for the Second graders, although with overall longer latencies and the apparent though not significant trend to respond more rapidly to True than False probes, there may be more of a self-terminating quality to their search. This uncertainty and the complete failure with kindergartners indicates that the task must be refined so that we may assess more precisely the behavior of the younger children. It seems quite clear that, qualitatively, the children are behaving in a fashion highly similar to that of adults.

As is typically found (Hohle, 1967; Katz & Wicklund, 1970b), the overall reaction times for younger children are slower. The Fourth graders are about 400 msec. slower than Sternberg's (1969) adults, but their slopes (57 msec. per item) are almost identical to the rate for adults scanning faces (56 msec. per item) and similar to the adult rates for scanning nonsense forms (46 msec. per item). Since the Ss of the present experiment are not highly practiced, it might be noted that the times are, if anything, inflated. The processes used by adults to search the memory for recent information appear to be well established in middle childhood. Studying these effects with younger children would seem desirable. Since the complex visual stimuli used here appear to be visually encoded even though simple verbal labels are readily available, it is of interest to explore the interactions of linguist and pictorial forms of the stimuli. Research is currently being conducted in this laboratory which tests the reactions to word probes for picture memory sets and picture probes for word memory sets as well as word-word and picture-picture (a replication of the present experiment) combinations. (See Experiment PRR-19 in this report).

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Table 1. Mean reaction times in msec. of second and fourth grade $\underline{S}$s for true and false responses for memory sets of 2, 4, and 6 pictures.

		Positive Set Size		
Grade	Probe	2	4	6
2	True	1216	1315	1313
	False	1165	1315	1358
4	True	913	1071	1139
	False	974	1051	1202

Table 2. Percentages of errors in each experimental condition.

		Positive Set Size		
Grade	Probe	2	4	6
2	True	5.00	17.50	25.60
	False	5.60	10.60	25.00
4	True	2.50	12.50	15.60
	False	3.75	5.00	19.90

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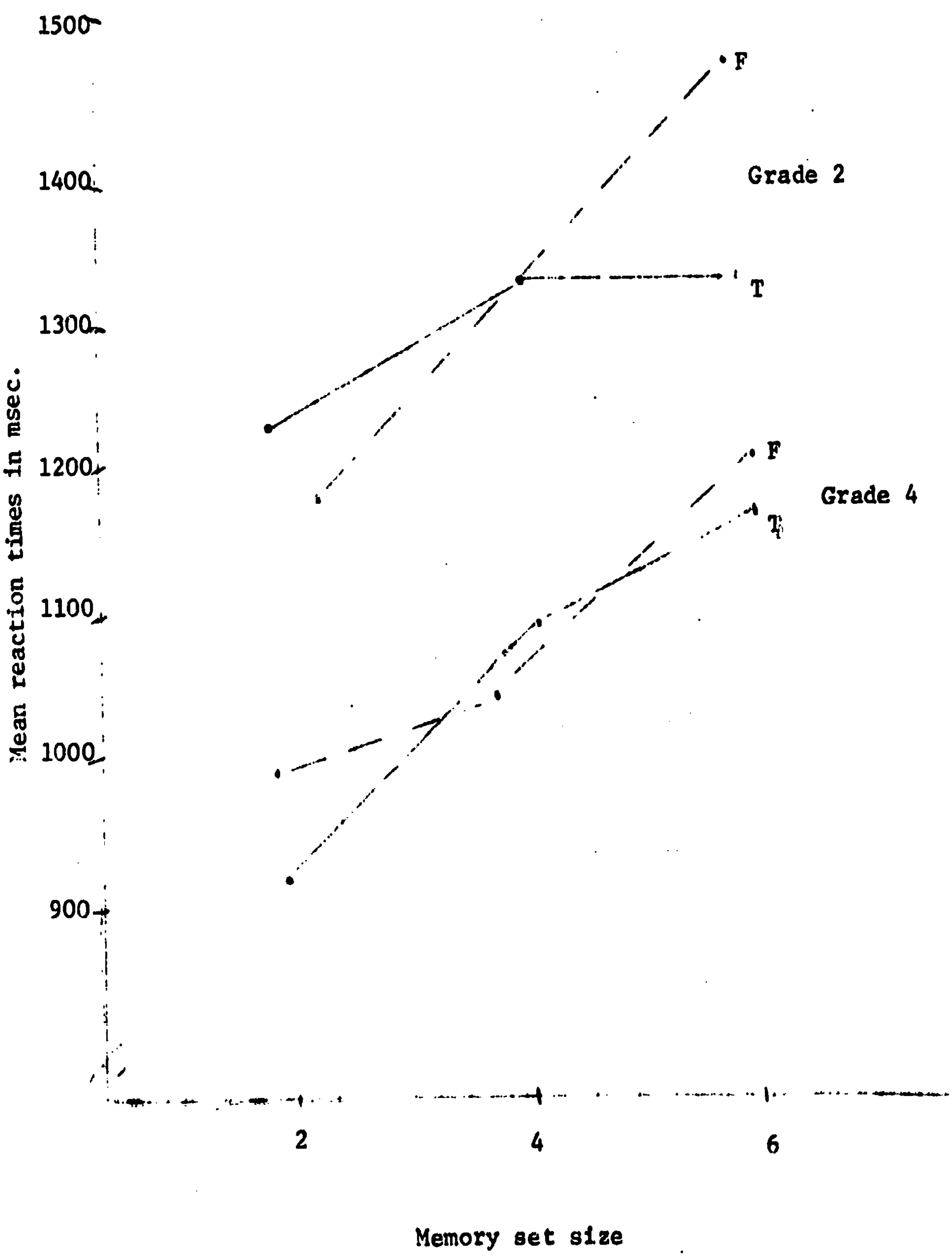
Figure 1. Mean reaction times in msec. as a function of memory set size for True and False responses of Second and Fourth grade children.



Memory Scanning Rates for Children in Grades One, Three and Five as a Function of Picture and Word Targets and Probes

In tasks requiring the rapid processing of relatively simple visual information Ss perform transformations on the visual information as it is stored. Physical information may be the most efficient code to use for matching two items separated by a very brief interval but the advantage of the physical match may disappear when the stimuli are separated by 2 sec. or more, depending on the type of stimuli (Posner, Boies, Eichelman & Taylor, 1969; Wicklund & Katz, 1970a). Ss appear to switch to a linguistic or naming code. When more than one item is stored and S is required to determine whether a probe is or is not amongst the set stored he engages in an exhaustive scan of the stored material (Sternberg, 1966). In addition, Sternberg (1967) has shown that the stored information is some transformation of the original stimuli to some "abstracted" form. Experiment PRR-7 in this report has supported that notion by showing that the form of the stimulus when presented to be memorized (digit, word, or dot pattern) does not influence recognition rate but the type of probe does. This suggests that all the stored items are encoded in a similar fashion and for this task the digit as probe was closest to the abstraction.

The present experiment is designed to explore further the nature of the transformation of visual information to memory and the retrieval of such information. We have shown that children use an exhaustive scan for pictures with a picture probe (Wicklund & Katz, 1970b). In this experiment we want to look at the possible interaction of type of memory set and type of probe using pictures and words. The data of Sternberg (1967) and Experiment PRR-7 argue against an interaction but recent findings by Klatsky and Atkinson (1970) suggest that different memory set-probe combinations do have a qualitative effect on processing. The present experiment is also concerned with developmental changes that might take place in the storage and retrieval of visual information.

Method

To date 30 Ss, 10 each in grades 1, 3 and 5 of the Pomfret Community School, Pomfret, Connecticut, have been tested. Additional data will be collected before the analyses are performed.

The stimuli for the memory set consisted of 2, 4, or 6 pictures or words drawn from a set of 10 Stanford-Binet pictures and the corresponding words (apple, bed, bird, car, clock, flower, hat, lamp, shoe, tree). Probe stimuli were single items, either a word or a picture that was or was not in the memory set. Both kinds of probes were used for both types of memory set yielding the following conditions: Word memory set, Word probe (WW); Word memory set, Picture probe (WP); Picture memory set, Picture probe (PP, a condition identical to the experiment of Wicklund and Katz, 1970b); and Picture memory set, Word probe (PW).

Stimuli were projected by means of a Kodak Carousel 850 slide projector onto a screen about 3 feet in front of the child. Exposure times for the memory sets depended upon the number of items in the set allowing 1 sec. per item (e.g. a 4 word memory set would be exposed for 4 sec.). The probe slide followed immediately separated only by the interval necessary for a slide change (940 msec.). Presentation of the second slide started a Synchron stop clock which was stopped by S's responding "yes" or "no" by pressing one of two telegraph keys. S was instructed to respond as rapidly as possible. E recorded the response latency and initiated the next trial.

Each S was presented 3 sets of 20 trials each. The first 4 trials of each set were dummy trials which will not be analyzed. S was given a brief rest between each set. The 48 test trials include two each of all the possible memory set, probe and true-false combinations in random order. The selection of items for conditions was counter-balanced such that all words and pictures occurred equally often as true or false probes and memory items.

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